(12) UK Patent Application (19) GB (11) 2 330 716 (13) A

(43) Date of A Publication 28.04.1999

(21) Application No 9722510.6

(22) Date of Filing 27.10.1997

(51) INT CL[6]
G01S 5/06

(52) UK CL (Edition Q)
H4D DPAB D23X D235 D512 D536 D561 D626

(56) Documents Cited
GB 1362343 A EP 0006594 A1 WO 91/16639 A1
US 5374936 A US 4916455 A

(58) Field of Search
UK CL (Edition P) H4D DMXX DPAB DPAC DPAX , H4L LDSL
INT CL[6] G01S 5/02 5/04 5/06 5/14 , H04Q 7/38

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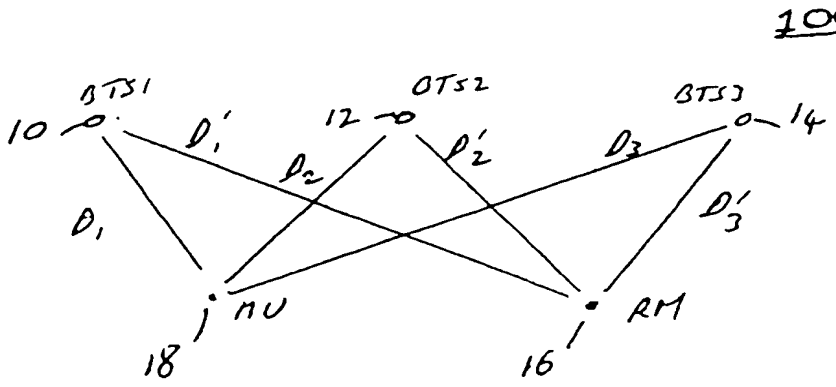
(54) Abstract Title
Position determination using a reference transmitter

(57) Three or more fixed base stations 10, 12 and 14 receive signals from a mobile unit 18 and a reference transmitter 16. The time differences of arrival (TDOA) of both the mobile and reference signals at the base stations are measured, and from the known locations of the base stations and the reference transmitter, the absolute position of the mobile unit can be determined without the need for synchronising the base stations.



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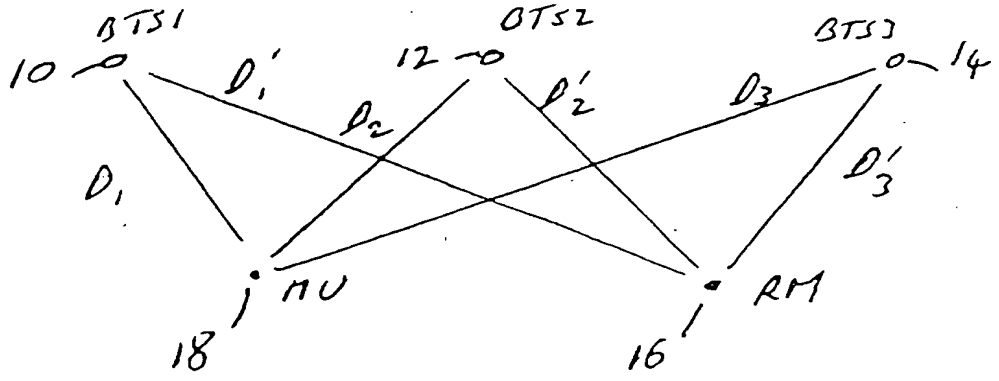

MOBILE COMMUNICATIONS SYSTEM

Field of the Invention

The present invention relates to a system and method of determining the position of a mobile unit in a mobile communications system.

Background of the Invention

In cellular communication systems, for example, there is at present no standard method of determining the actual location of a mobile unit in communication with a fixed base unit of the system. With the growth in mobile communication systems, certain national authorities are asking for methods to be developed which are able to locate a mobile unit for use, for example, by emergency services, for navigation and the like.

Summary of the Invention

The present invention seeks to provide a system for determining the position of a mobile unit of a mobile communications system.

According to an aspect of the present invention, there is provided a system for determining the position of a mobile unit of a mobile communications system including three or more fixed receivers spaced from one another; a reference transmitter spaced from the fixed receivers and operable to transmit a reference signal to the receivers; and processing means operable to determine on the basis of a signal from a mobile unit in communication with the fixed receivers and of the reference transmitter the position of the mobile unit.

Locating the mobile unit in this manner can be useful for emergency services, navigational systems and the like.

Preferably, the reference transmitter is a reference mobile unit.

The processing means is preferably operable to determine the differences in times of arrival of the signals from the mobile unit and the reference transmitter and to determine therefrom the position of the mobile unit.

The fixed receivers may be separate base stations, separate antennae, or antenna elements of an adaptive antenna array.

According to another aspect of the present invention, there is provided a method of determining the position of a mobile unit of a mobile communications system including the steps of transmitting a reference signal from a fixed transmitter to at least three fixed receivers which are spaced from one another; transmitting a signal from a mobile unit to the fixed receivers; and determining on the basis of the signal from the mobile unit and of the reference transmitter the position of the mobile unit.

Preferably, the step of determining the position of the mobile unit includes the step of determining the differences in times of arrival of the signals from the mobile unit and the reference transmitter.

Brief Description of the Drawing

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawing, in which the sole figure is a schematic view of a preferred embodiment of a system for determining the position of a mobile unit.

Description of a Preferred Embodiment

Referring to the figure, the preferred embodiment of mobile unit location system is designed for use in a mobile communications system, for example a GSM network.

In each cell of the mobile communications system 100 there is provided a plurality of fixed receivers 10, 12, 14, which in this example are shown as base stations BTS1-BTS3. In other examples, the base stations BTS1-BTS3 may be individual antenna elements of an adaptive antenna array.

The system 100 also includes a reference transmitter, which in this example is shown as a reference mobile 16.

Mobile unit 18 is a user unit of conventional type and which it is desired to locate relative to the base stations 10-14. The position of the mobile unit 18 could be used, for example, by emergency services or for the purposes of offering position related navigation or other information.

In use, the mobile unit 18 transmits uplink signals as and when required, which are received at each base station 10-14. As the distance D1-D3 from the mobile unit 18 to each base station 10-14 is different, the time of arrival of the uplink signal to the base stations 10-14 will differ. In practice, the uplink signal used for positioning purposes may be the RACH burst or any other known data signal.

As the base stations 10-14 are not time synchronised, the differences in times of arrival of the uplink signal alone cannot be used to determine the position of the mobile unit 18. Even if the base stations are nominally synchronised there may typically be small but significant time offsets between them.

A reference transmitter 16, in the preferred embodiment of a reference mobile, sends a reference uplink signal which also arrives at the base stations 10-14 at different times as a result the difference in distances D_1'-D_3' of the reference mobile 16 to the base stations 10-14. As the position of the reference mobile 16 is known, the time differences of the reference uplink signal can be used to determine the position of the mobile unit 18. The reference uplink signal could in practice be the same as the known signal used for the mobile unit 18 or any other known signal.

More specifically, six signal waveforms are produced, from which the following time differences can be determined:

$$\Delta T_{12} = D_1 - D_2 + O_1 - O_2$$
$$\Delta T'_{12} = D'_1 - D'_2 + O_1 - O_2$$

$$\Delta T_{13} = D_1\text{-}D_3 + O_1\text{-}O_3$$
$$\Delta T'_{13} = D'_1\text{-}D'_3 + O_1\text{-}O_3$$

$$\Delta T_{23} = D_2\text{-}D_3 + O_2\text{-}O_3$$
$$\Delta T'_{23} = D'_2\text{-}D'_3 + O_2\text{-}O_3$$

where ΔT_{12} is the time difference of the mobile unit 18 uplink signal reaching the first and second base stations 10, 12; $\Delta T'_{12}$ is the time difference of the reference mobile 16 uplink signal reaching the first and second base stations 10, 12; O_1, O_2 and O_3 are random but fixed offsets representative of the synchronisation errors between the base stations 10, 12 and 14.

For the above equations, given that D'_1, D'_2 and D'_3 are known, the differences $D_1\text{-}D_2$, $D_1\text{-}D_3$ and $D_2\text{-}D_3$ can be calculated and the position of the mobile unit 18 relative to the base stations 10-14 determined. Given that the positions of the base stations 10-14 are known, the absolute position of the mobile unit 18 can thus be established.

Processing means operable to calculate the position of the mobile according to the described method is preferably implemented by a software program running on processing hardware as apparent to the skilled person. The processing means may be disposed in the mobile unit the reference mobile, the basestation or in a separate processor.

The example given above provides a solution in two dimensions for the location of the mobile unit, assuming that the height differences between the base stations, the reference unit and the mobile unit are negligible. The skilled person may apply the method to a solution in more dimensions without detracting from the current invention.

The reference mobile 16 may be a standard mobile unit located at a known position and may be permanently registered with the base stations 10-14. The reference mobile 16 may also be located very close to and even with the base stations 10-14. As the purpose of the reference mobile is merely to

provide the reference signal, a call to the reference mobile 16 need not be set up, the RACH bursts could be ignored.

In principle, the BCCH channel receiver system could be used for serving cell measurements. However, transmission from other cells could not be received in this way, so a separate receiver system would be required, which could readily be provided by an omni antenna.

The communication link between the base stations 10-14 will be readily envisaged by the skilled person, in dependence in particular upon the actual implementation of the base stations 10-14.

Claims

1. A system for determining a position of a mobile unit of a mobile communications system including at least three fixed receivers spaced from one another; a reference transmitter spaced from the at least three fixed receivers and operable to transmit a reference signal to the at least three fixed receivers; and processing means operable to determine the position of the mobile unit using at least a signal from the mobile unit and received at the at least three fixed receivers and a second signal of the reference transmitter.

2. A system according to claim 1, wherein the reference transmitter is a reference mobile.

3. A system according to claim 1 or 2, wherein the processing means is operable to determine differences in times of arrival at each of the at least three fixed receivers of the first signal from the mobile unit and the second signal from the reference transmitter and to determine therefrom the position of the mobile unit.

4. A system according to claim 1, 2 or 3, wherein the at least three fixed receivers are chosen from a group consisting of base stations, antennae, or antenna elements of an adaptive antenna array.

5. A method of determining a position of a mobile unit of a mobile communications system including the steps of transmitting a first reference signal from a reference transmitter to at least three fixed receivers which are spaced from one another; transmitting a second signal from the mobile unit to the at least three fixed receivers; and determining the position of the mobile unit using at least the second signal from the mobile unit and of the first reference signal of the reference transmitter.

6. A method according to claim 5, wherein the step of determining the position of the mobile unit includes the step of determining the differences

in times of arrival of the first and second signals from the mobile unit and the reference transmitter at each of the at least three fixed receivers.

7. A system for determining a position of a mobile unit of a mobile communication system substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

8. A method of determining the position of a mobile unit of a mobile communication system substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

The Patent Office

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Application No: GB 9722510.6
Claims searched: All

Examiner: Matthew Nelson
Date of search: 16 March 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4D (DPAB, DPAC, DPAX, DMXX); H4L (LDSL)

Int Cl (Ed.6): H04Q 7/38; G01S 5/02, 5/04, 5/06, 5/14

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1362343	(SIEMENS) See figure 1 & page 6, lines 44-122.	1-6
X	EP 0006594 A1	(SIEMENS) See figure 1 & abstract.	1,2,4 & 5 at least
X	WO 91/16639 A1	(RUSSELL) See abstract	1-6
X	US 5374936	(FENG) See whole document	1-6
X	US 4916455	(BENT et al) See col. 4, lines 34-49	1,2,4 & 5

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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